PERFORMANCE AND AERODYNAMIC CHARACTERIZATION OF SUPERSONIC RETROPROPULSION FOR MARS ENTRY, DESCENT, AND LANDING

(IPPW-7)

ASHLEY M. KORZUN*

Georgia Institute of Technology
e-mail: *akorzun@gatech.edu*

ABSTRACT

To date, the United States has landed six robotic missions on Mars. Including missions planned for this decade, the largest entry mass sent to Mars will be Mars Science Laboratory at ~ 3250 kg.[1] The entry, descent, and landing (EDL) systems for these missions rely heavily on extensions of Viking-heritage technology, namely supersonic Disk-Gap-Band parachutes and 70-deg sphere-cone, blunt-body aeroshells. Supersonic deceleration has been identified as a critical deficiency in extending these heritage technologies to high mass, high ballistic coefficient systems.[1,2] System-level studies to assess the required performance of high-mass entry systems recommend the development of alternative supersonic decelerators, a challenge potentially addressed by supersonic retropropulsion (SRP).[1]

Prior high-mass Mars EDL systems studies have neglected aerodynamic-propulsive interactions and subsequent performance impacts during the supersonic phase of descent. The objectives of this work are to accurately evaluate the performance of supersonic retropropulsion as a function of vehicle ballistic coefficient and maximum allowable system *T/W* using an experimentally derived aerodynamic-propulsive interactions model to define a range of initiation conditions relevant for future high-mass Mars entry systems.

Across a wide range of ballistic coefficients, mass-optimal Mars entry trajectories for vehicles utilizing supersonic retropropulsion are characterized by extended phases of near-constant altitude deceleration deep within the atmosphere, shallow flight path angles at SRP initiation to minimize gravity losses, and initiation conditions that minimize the required propulsive ΔV. These conditions generally imply SRP initiation at the minimum altitude boundary defined by the timeline considerations of the subsequent EDL events. SRP initiation conditions are a strong function of the thrust available, and for all cases considered here, the SRP phase relies on no drag preservation to reach subsonic conditions with timeline margin.

Little work exists in the literature on computational simulation of supersonic retropropulsion flowfields.[3] The objective of this work is to anchor two existing computational tools to existing experimental data for central and peripheral configurations. Included are an assessment of the applicability of inviscid approaches to conceptual design and a preliminary definition of best practices for simulating supersonic retropropulsion flowfields using viscous approaches. Anchored computational tools and approaches contribute to the development of higher-fidelity models for performance analyses of entry systems utilizing supersonic retropropulsion.

---

[1] Braun, R.D., and Manning, R.M., "Mars Exploration Entry, Descent, and Landing Challenges," *Journal of Spacecraft and Rockets*, Vol. 44, No. 2, 2007, pp. 310-323.
[2] Christian, J.A., Wells, G.W., et al., "Extension of Traditional Entry, Descent, and Landing Technologies for Human Mars Exploration," *Journal of Spacecraft and Rockets*, Vol. 45, No. 1, 2008, pp. 130-141.
[3] Korzun, A.M., Braun, R.D., and Cruz, J.R., "Survey of Supersonic Retropropulsion Technology for Mars Entry, Descent, and Landing," *Journal of Spacecraft and Rockets*, Vol. 46, No. 5, 2009, pp. 929-937.